Global Value Chains and Innovation Systems: Exploring the Inter-relations

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Advances in transportation sector have shrunk the world in a matter of few hours while the inventions in information and communication technologies is giving time a miss. These together have transformed the structure of world production process. The nations are increasingly concerned about entering the global value chains (GVC) and subsequently to upgrade into higher value-added activities, largely being determined by the structure of their innovation systems (IS). Therefore, an attempt is made to examine the relationship between participation in Global value chains (GVC) and Innovation Systems (IS) of different developed, Asian and developing countries depicting different stages of development. For the purpose, seemingly unrelated regression equation model is estimated for the manufacturing industries and it was found that in the initial stages of development, low-skilled labour, medium-skilled labour, process innovation and price level have significant impact on participation in global value chains (GVC) followed by the role of skilled labour and innovations in the advanced stages of development. It was also found that for building innovation systems (IS), the role of high-skilled labour predominates in the initial stages. However, in the later stages, participation in GVC with backward linkages also has a positive impact on building their innovation

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systems (IS). Specifically for South Korea with proximity in high-technology intensive industries, the impact of high skilled labour, product and process innovation are significant in determining global value chain participation while the high-skilled labour and backward linkages played important role for building its innovation systems (IS). For India's low-technology intensive industries, low skilled labour and price level have significant impact on its participation in global value chains whereas human capital have positive impact on its innovation systems (IS).

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I. Introduction

Change is inevitable. The dynamism in human inquisitiveness can be captured through times. Beginning with the invention of wheel, to the invention of steam engines, the transportation sector has shrunk the world in a matter of few hours, while the invention of communication technologies has given time a miss. These, together has transformed the structure of the world economies and more importantly, the structure of world production process. Adam Smith's (1776) dexterity of the workers in the infamous pin factory has taken an altogether another level with workers contributing from different geographies (Gereffi and Stark 2011) with specializing in different "tasks" (Grossman and Rossi-Hansberg 2008) giving a new dimension to Ricardo's (1817) comparative advantage by strategically managing and building specific Heckscher and Ohlin's (Leamer 1995) factor endowments. The specialization in tasks, whose dimension is reducing at a fast pace, is surpassing the national boundaries, leading to the emergence of studies related to global value chains (GVC). Pioneered by the work of Porter (1990), it got the wider dissemination henceforth. Global value chains (GVC) is a concept that encompasses a full range of activities that requires bringing a good from its inception to the final consumer channeling from product design to its distribution (Cattaneo *et al.* 2010; Prete *et al.* 2018) with contributions from different geographies.

However, the contribution in global value chains (GVC) determines nations competitiveness making them interested in entering the global value chains (GVC) and subsequently to upgrade into higher value-

generating activities that however subsumed into the structure of nation's capabilities (Porter 1990) that evolves continuously over time. The broader realm of innovation systems approach (IS) (Freeman 1987; Fagerberg *et al.* 2005a) helps in understanding the dynamics of capability accumulation.

However, it was found that the two paradigms of knowledge, the global value chain (GVC) approach and Innovation systems (IS) approach were studied separately until efforts were initiated to combine these two (Jurowetzki *et al.* 2018; Pietrobelli and Rabellotti 2009, 2011). It was also found that the combined literature on global value chains (GVC) and its relationship with innovation systems (IS) largely confines to case studies and theoretical underpinnings. The distinct theoretical disciplinary foundations of global value chains (GVC) and innovation systems (IS) pose challenge of combining the two approaches. With the former embedded strategic management, economic geography (spatial configuration), economic sociology (inter-organizational relations between economic actions and social structures), development economics (Hess and Yeung 2006) and also neo-classical approach with emphasis on competitiveness (Selwyn 2013), the latter is evolutionary in nature (Jurowetzki *et al.* 2018) with the clear and strategic role of public policy.

Specifically, the present paper tries to examine the relationship between participation in global value chains (GVC) and innovation systems (IS). In the contemporary fast moving technological frontiers, building stronger innovation systems (IS) and contributing more in global value chains (GVCs) is becoming important. A strong innovation system (IS) is expected to contribute more in global value chains (GVC), and the later is also expected to build the strong innovation systems. But this process is far from simple and automatic. In this context, an attempt is made in the paper to compare and examine the relationship between GVC and IS for developed, Asian and developing economies.

The structure of the paper is as follows. Besides the present section on Introduction, Section II presents broadly the framework of global value chains (GVC) and innovation systems (IS) approach. Section III explores the relationship between global value chains and innovation systems for chosen countries groups. In section IV, a comparison between high-tech and low-tech manufacturing industries from South Korean and Indian manufacturing sector is presented and discussed. Section V concludes and provides the major policy implications.

II. Fragmented Production Process and Indigenous Capabilities

A. International Fragmentation[1] of Production Process

Hopkins and Wallerstein had conceived the term commodity chains in a paper published in 1977 and defined it as the "linked set of processes", far from any "linear trend" that got transformed from "within the boundaries of state" to "crossing state boundaries" (ibid). Importantly, they also emphasized the role of state machinery "to create or destroy monopolies, to subsidize or render more expensive productive activities, to destroy or protect produced goods" (ibid). The French version of value-chains known as Filiere, however has a narrow scope with confinement within national boundaries and that too of agricultural commodities during the 1960s (Kaplinsky and Morris 2002; Raikes *et al.* 2000). In 1990, Porter coined the term "value chains" in his book *The Competitive Advantage of Nations*. He defined it as "interdependent system or network of activities connected by linkages". Henceforth, 1990s saw the proliferation of the term value chains (Kaplinsky 2000) largely due to the paradigm shift towards increasing globalization with falling tariff rates and internationalization of firms. Concurrently, Gereffi (1994) coined the term "global commodity chain" (GCC) but was criticized for the use of word commodity implying the "production of undifferentiated products" (Kaplinsky 2000). However, the inclusion of governance structure and the distinction between producer and supplier driven supply chains are the significant contribution of GCC literature (Bair 2005). Specifically, Porter's "economic-developmental framework" mainly concerns with the inter-firm networks while the "business-managerial approach" (Henderson *et al.* 2002) of Gereffi and colleagues lies in corporate powers and institutional arrangements (ibid).

But early 2000 saw a plethora of literature with divergent terminologies.[2] Borrus *et al.* (2000) in the introduction chapter of their book on Asian economies argues that the "region is increasingly linked

[1] The term is used by Arndt and Kierzkowski (2001) where they emphasized that fragmentation is an old phenomenon, probably from the beginning of Industrial Revolution.

[2] Bair (2005) discusses the different terminologies that lead to the adoption of common terminology of global value chains (GVC).

across borders … that span the entire value chain of the commodity" which they termed as "cross-border production network (CPN)/ international production network" which could be one reason for the rapid transmission of economic problem from one Asian country to another during the economic crisis of 1997. They also argue that long-term recovery of the region requires "increasing networked production structures". In a paper published in 2002, Ernst used the term "Global Production Network" that provides the opportunities for "international corporations to access the low cost capabilities overseas to complement their competencies". Claimed to use the concept of "global production network" (GPN) contemporarily although independently with Ernst's 1998, Henderson *et al.* (2002) found that GPN has "supersede the transnational corporations as the effective form of industrial organization". It was, however interesting to find that in a paper published in 2005, Gereffi *et al.* used the term global value chains (GVC) for the "globalization of production and trade" with the concern to adopt a common terminology for the work related to "production networks related to global economy[3]" (Bair 2005).

B. Indigenous Capabilities in System of Innovation Approach

An idea can come to anyone anywhere, but its commercial application can be possible in firms that seldom do these innovations in isolation (Fagerberg 2005b). Knowledge, skills, capabilities, resources are factors that could be supplied through various firms and non-firms organizations[4] and institutions (Edquist 2005) that together form a "system" that generate "innovations" which Freeman (1987) called "national innovation systems" (NIS) (ibid) in the book on Japanese innovation systems. Theoretical elaboration of the concept by focusing on the evolutionary character in the process of innovation of interactive learning among actors was done by Lundvall in a book published in 1992. Another influential book on the national systems of innovation

[3] In September, 2000 research network was formed that can be reached at www.globalvaluechain.org.

[4] Organizations are composed of various actors that are created as formal structures (Edquist 2005). Organizations may be other firms like suppliers, customers or competitors while non-firms organizations may be universities, schools and government ministries (ibid).

(NIS) was published in 1993 edited by Nelson in which a comparative analysis of the national innovation system (NIS) of different countries was done. National innovation systems (NIS) of five relatively affluent countries like United States, Japan, France, Germany and Italy; followed by the inclusion of four small countries with high incomes like Denmark, Sweden, Canada and Australia were taken and were compared with five lower income countries striving for industrialization. The massive comparative analysis reflects that the differences in the innovation systems of these countries reveal the economic and political structure of these countries.

Some close variants of national innovation system (NIS) like Regional System of Innovation (RIS), Technology Innovation System (TIS) and Sectoral Innovation System (SIS) approach also emerges during the mid 1990s. Edquist (2005) clustered these three perspectives together and termed them "systems of innovation" approach while reflecting upon the main characteristics and their complementary nature. The observation of "spatial concentration of industries" for the nature of some "knowledge being tacit" led the emergence of the concept of regional innovation system (RIS) in early 1990s (Asheim and Gertler 2005, Cooke *et al.* 1997). Technological Innovation System (TIS) is largely confine to infrastructure that "involves in generation, diffusion, and utilization of technology" (Carlsson 1995). Sectoral Innovation System (TIS) approach concentrate on specific sector composed of a group of firms. However, contrary to national innovation systems (NIS), Malerba (2005) regarded sectoral innovation system (SIS) to "have local, national and/or global dimensions, that can coexists in a sector". Interestingly, under systems of innovation, "innovation activities of firms depend heavily on external sources" (Fagerberg 2005b) signifying inter-linkages between different national innovation systems (NIS).

C. Bridging the gap between NIS and GVC: Nature of Knowledge

Romer (1990), Grossman and Helpman (1991) brought knowledge out of the black-box that possess public good characters like non-rivalry and non-excludable making it spillover from knowledge producers to knowledge users (Keller 2004). There are however numerous channels of technological spillovers. Jaffe (1989), Jaffe, *et al.* (1993) found the impact of codified form of university research on the extent of patents by the local firms. Almedia and Kogut, (1997) found the transfer of

knowledge by the movement of people/ scientists. Coe and Helpman, (1995), Keller (2004) found that technological flow of knowledge could be embodied in trade. But the literature found difficult to capture "unintended informal knowledge spillovers" (Howells 2002) with the greatest challenge about the tacit nature of knowledge that is sticky. Stickiness of knowledge is the basic premise of national innovation system (NIS) (Ernst 2002). Speed and variation of the diffusion of innovation is associated with the absorptive capacity (Cohen and Levinthal 1989) of the firms/ countries. Bathelt *et al* (2004) found that firms learn more with global inter-connections arguing that institutional and infrastructural support is required for global networking emphasizing upon the importance of rate of adoption (Hall 2005) that Cohen and Leventhal (1989) termed as absorptive capacity. In 2002, Ernst highlighted the greatest weakness of national innovation systems (NIS) approach of not taking into concentration the international integration and its impact on various countries. The basic proposition of the paper was that the global production network (GPN), can also acts as a means of international knowledge spillover that could help, especially the developing countries in up-grading their national innovation systems (NIS). Continuous learning and strategic innovation are key determinants of competitiveness and growth of nations, industries and firms (Pietrobelli and Rabellotti 2009). But leaning and innovation capabilities are determined by larger macroeconomic process of National Innovation Systems (NIS) in which the multiple institutions and organizations interact and co-evolve. Pietrobelli and Puppato (2015) found that the scarcity of resources and technological development are the constraints before many developing countries. They argued that specific industrial and technological foresight is required to strengthen their national innovation systems (NIS) that could help them to gain from global value chains (GVC). Citing the example of South Korea, the authors argued that the country adopted specific industrial policies to achieve unprecedented fast economic growth. Henceforth, research for understanding the relationship between IS and GVC was emphasized[5] by the scholars (Jurowetzki *et al.* 2018). Marchi *et al.* (2018) examines the role of GVC in transferring knowledge to developing countries. Using

[5] The European Journal of Development Research had a Special issue on 'innovation systems in the era of global value chains' in 2018.

cluster analysis approach, the authors identified the cases of innovators who gained knowledge within GVC at different degrees. Lee *et al.* (2018) argues that in the initial stage, the successful firms learn from participation in GVC followed by a stage of disintegration for building local value chains that later followed with the stage of reintegration in GVC, which they termed as "in-out-in again" hypothesis. Keijer and Iizuka (2018) explores the IT-enabled services sector in South Africa that participate in local and regional value chains for learning and capability building. Sampath and Vallejo (2018) empirically examined the case of integration of 74 developing countries for three years and found that dynamism of participation in global trade and exports is the result of technological capabilities across export categories. Tajoli and Felice (2018) found empirically that participation in GVC, especially by developing countries has positive impact on their innovation outcomes. Similarly, Fagerberg *et al.* (2018) examined the hypothesis of increased participation in GVC that lead to higher economic growth while considering the data for 125 countries over the period 1997-2013 of which they found a strong link. However, they highlight that building innovation system is important for benefitting from participation in GVC. Pietrobelli and Staritz (2018) argue that GVC related policies and programs could provide opportunities for firms, especially from developing countries. Thus, it was evident that the researchers are exploring the relationship between innovation system and participation in GVC wherein the present research also aims to contribute.

III. Global Value Chains and Innovation Systems: Analysis of Manufacturing Industries

To reiterate, the aim of the paper is to examine the relationship between participation in global value-chains and innovation systems approach. Seemingly unrelated regression equation model is applied to examine (i) the impact of various innovation systems related indicators for participation in global value chains and (ii) the impact of various global value chains related indicators for building the innovation systems. Such an analysis is supposed to contribute in the existing literature by emphasizing upon the empirical evidences of the relationship between global value chains (GVC) and innovation systems (IS) approach. The analysis is aimed for policy implication in a manner that can help in building strong innovation systems (IS) with the

participation in global value chains (GVC) and vice-versa. This analysis is particularly helpful for various followers that are in the process of catch-up with the frontrunners and for the later to sustain their position.

A. Variables: Indicators, Nomenclatures and Sources

Based upon two conceptual underpinning, the need is to choose the variables (Appendix I, Table A.2.) that can best capture to signify the concept of global value chains (GVC) and innovation systems (IS) approach. The rationales of the chosen variables are discussed as follows.

(a) Global value chain participation index (GVCPI): Participation in GVC is the summation of backward linkages and forward linkages within GVC (Koopman 2010; Escaith and Gaudin 2014; Wang *et al.* 2017; Jouanjean *et al.* 2017). Backward linkage is defined as import content of exports and forward linkage as the export of domestic value-added that is further exported by the importers. The data for both backward linkages and forward linkages were extracted from OECD-TiVA database. Backward Linkages (FVASH) and Forward Linkages (DVAFXSH) are added to construct the GVC participation index (GVCPI) (Appendix I, Table A.2). In the analysis, GVC participation index (GVCPI) is the dependent variable while the backward linkage (FVASH) and forward linkage (DVAFXSH) are independent variables in the model with Innovation System index (INNI) as the dependent variable.

(b) *Innovation systems Index (INNI)*: Choice of indicators that reflects innovation systems is very tricky to choose. Quantitatively, innovation system can be examined by innovation inputs and outputs and the variables reflecting inter-relationship between various variables. Usual innovation input variables includes investment in research and development (R&D), human capital *etc.* while innovation output is reflected with the variables including gross domestic product (GDP), high-technology trade as a proportion of exports, patents *etc.* (Smith 2005). But all these indicators also have serious limitation of one type or another (ibid). Moreover, it is also very complex to capture the variables related to inter-relationship between various actors. Therefore, in the present analysis, data reflecting innovation systems in the form

of innovation performance indicators are extracted from UNESCO-institute for statistics (UIS) that provides comparable innovation related dataset for manufacturing sector of 71 countries. Based upon the "Oslo Manual, the data is collected from different countries for maximum international comparability.[6]" The variables like Product Innovation, Process Innovation, Organizational Innovation and Marketing Innovation (discussed below) reflects the proportion of firms that are engaged in each of the respective innovation signifying the holistic mechanism of "innovation implemented by firms, innovation activities and linkages used" (ibid).

(i) *Product Innovation (PRODI)*: UNESCO-UIS statistics uses OECD and Eurostat Oslo manual guidelines for collecting and interpreting innovation while estimating the firms that implemented product, process, organizational and marketing innovation. UNESCO-UIS statistics regarded product innovation as the "significant improvements in technical specifications, components and materials *etc*. in the good". The variable captures the percentage of product innovators in manufacturing by different size classes including micro, small, medium-sized and large firms. Thus, the variable can be taken as one of the variable to proxy "innovation systems", reflecting the comparable picture of manufacturing industries from different countries[7]. However, the data for these variables are available for few years and for analytical purpose, it is assumed that the proportion of firms doing product innovation does not change significantly in short duration. So we used the same proportion for all the non-reporting years, *i.e.* preceding and successive years till the next reported data. It is expected that the impact of product innovation would be positive on participation in global value chains. However, it would be important to examine whether the impact of this variable would be similar for different counties and sectors.

(ii) *Process Innovation (PROCI)*: UNESCO-UIS statistics defined process innovation as "the implementation of a new or significantly improved production or delivery method". The indicator captures

[6] http://uis.unesco.org/sites/default/files/documents/ip37-summary-report-of-the-2015-uis-innovation-data-collection-2017-en.pdf

[7] The survey provides comparable data for different countries (Iizuka and Hollanders 2017).

the percentage of firms that are engaged in process innovation out of the total firms in different countries at different time. It is expected that the impact of process innovation would be positive for participation in global value chains.

(iii) *Organizational Innovation (ORGI)*: The variable captures the percentage of firms in manufacturing sector of respective countries that "implement new organizational method in the firm's business, workplace organization or external relations". It is assumed that the impact of organizational innovation would be positive for participation in global value chains from different countries and sectors as it involves innovation in workplace along with building external relations with different entities.

(iv) *Marketing Innovation (MARKI)*: The percentage of firms that implement a "new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing". Therefore, it is expected that marketing innovation would helps in participation in global value chains through innovations in product promotion with various innovative means.

The average of product innovation (PRODI), process innovation (PROCI), organizational innovation (ORGI) and marketing innovation (MARKI) is taken to capture Innovation Systems Index (INNI). These four different forms of innovation are reflection of evolution of various actors, organizations and institutions. Therefore, in the analysis, the variable Innovation Systems Index (INNI) is the dependent variable while the four variables- product innovation (PRODI), process innovation (PROCI), organizational innovation (ORGI) and marketing innovation (MARKI) are independent variables in the model with GVC participation index (GVCPI) as the dependent variable. The following are other variables that are chosen for the present analysis.

(c) *Human Capital* (LABHS/LABMS/LABLS): Human capital is important for building innovation systems (IS) as well as in increasing the participation in global value chains (GVC) (Pietrobelli and Rabellotti 2009). World Input-Output Database (WIOD) 2013 was release in the year 2014 and it provides data for different variables for the different

sectors from 1995 to 2011[8]. The socio-economic accounts of WIOD' 2013 contains data related to labour compensation depending upon skills as a share of total compensation. It needs to be highlighted that the latest WIOD' 2016 that was released in 2018 does not include the required variable related to human capital. So, in the present study, the earlier release of WIOD' 2014 database is used and the values are forecasted[9] for missing years to make that dataset balanced for the analysis. WIOD' 2013 provides the shares in compensation provided to high-skilled labour (LABHS), medium-skilled labour (LABHS) and low-skilled labour (LABLS) that adds to unity (Appendix I, Table A.2.). Importantly, WIOD' 2014 provides data for the individual two digit industries for different countries and average was taken to arrive at the national estimates. It is expected that high-skilled labour (LABHS) is relatively more useful in building the innovation systems (IS) for different countries. However, it is also expected that high-skilled labour (LABHS) would be having relatively more impact on participation in global value chains (GVC) by developed countries and high-technology intensive sectors whereas it would be low-skilled labour (LABLS) that probably is playing an important role for participation of developing countries into GVC, due to the cost factor. Therefore, the results of the impact of high-skilled labour (LABHS), medium-skilled labour (LABMS), and low skilled labour (LABLS) on global value chain participation index (GVCPI) and innovation systems index (INNI) for developed, developing and Asian economies (Appendix I, Table A.1.) would be interesting to examine so as to decipher the policy implications.

(d) *Price Level (PL)*: Price level is assumed to play an important role in the pattern of international production systems. Literature (Hummels *et al.* 2001) argues that to save cost of production, the redundant jobs are usually shifted to lower-cost producing countries. Therefore, to examine the impact of price level, the data for "price level ratio of PPP conversion factor (GDP) to market exchange rate" is taken from World Development Indictors (WDI). The variable captures the number of units of a country's currency required to buy the same amount of goods and

[8] For some countries and variables the data is available till 2009.

[9] The forecast function in Microsoft Word is used to predict future value of y while considering the past known values of y's as dependent variable with time t's as independent variables.

services in the domestic market as a U.S. dollar would buy in the United States of America. The ratio is also known as National Price Level that helps in comparison of cost of bundle of goods that makes up the gross domestic product (GDP) in different countries. The value is based on 2011 International Comparison Program database. It is expected that the price level (PL) would have a negative relationship with global value chain participation index (GVCPI) whereas the impact of price level (PL) for building innovation system (INNI) is uncertain for different group of countries (Appendix I, Table A.1.).

Control variables: To examine the effects of the above variables of interest, certain controls (as discussed below) are included along with time and country dummies. However, for the exercise in Section 4 for the South Korean and Indian manufacturing sector, certain specific control variables (discussed in section IV) along with time and industry dummies are included.

(e) Communication (internet): Individuals using Internet as a percentage of population is included as a control variable that is expected to have an impact on both innovation systems index (IS) and global value chains participation index (GVCPI) as a mechanism of linkages for information flows. The variable is extracted from the website of world development indicators (WDI) that provides a comparable data for about 264 countries.

(f) Logistics (logistics): Logistics performance Index (LPI) depicts the quality of trade and transport related logistics is extracted from World Development Indicators (WDI). This indicator shows a comparative picture of trade and transport related logistics of various countries. The survey covers important indicators like customs, infrastructure, international shipments, tacking and tracing and timeliness to construct the logistic performance index (LPI). The data ranges from 1 to 5 (low to high) and is available from 2005 to 2016, however with a gap of one year. Therefore the preceding values were used for the missing values to make the dataset balanced.

(g) Initial Gross Domestic Product per capita (GDPPC): Taken from World Development indicators (WDI), this indicator reflects the size of the economy and is included in the model with different industrial groups.

(h) Share of Manufacturing (manf): Manufacturing value added as a percentage of gross domestic products (GDP) is taken from World development indicators (WDI) to control for the size of the manufacturing industries for the regression analysis for different countries.

(i) Research and Development (R&D): Research and Development expenditure as a percentage of gross domestic product (GDP) is used to control the important innovation input indicator that is expected to have an impact on both innovation systems index (IS) and global value chains participation index (GVCPI). The variable is extracted from World Development Indicators (WDI).

B. Global value chains and Innovation Systems: The Model

Following model is constructed to examine the relationship between global value chains participation index (GVCPI) and the Innovation Systems Index (INNI).

GVC participation index =f (Innovation systems index, human capital, price level, control variables, country and time effects)

Innovation systems Index = f (GVC participation index, human capital, price level, control variables, country and time effects)

The estimation model takes the following form:

$$GVCPI_{i,t} = \alpha_{0,i,t} + \alpha_1 PRODI_{i,t} + \alpha_2 PRODI_{i,t} + \alpha_3 ORGI_{i,t} + \alpha_4 MARKI_{i,t} + \alpha_5 LABHS_{i,t} + \alpha_6 LABMS_{i,t} + \alpha_7 LABLS_{i,t} + \alpha_8 PL_{i,t} + controls + u_{i,t}, \text{ and}$$

$$INNI_{i,t} = \beta_{0,i,t} + \beta_1 FVASH_{i,t} + \beta_2 DVAFXSH_{i,t} + \beta_3 LABHS_{i,t} + \beta_4 LABMS_{i,t} + \beta_5 LABLS_{i,t} + \beta_6 PL_{i,t} + controls + u_{i,t}$$

The relationship between two equations with different explanatory variables is estimated through Seemingly Unrelated Regression estimation (SURE) technique. SURE also helps in capturing the impact of "correlation of disturbances across equations" (Baltagi 2005) contemporaneous. The model was estimating with STATA 14 software.

In the model, α's and β's are the coefficients of interest with controls along with country and time dummies. All the variables in the model

are in log form. The variables names, numenclature and sources are presented in Appendix I, Table A.2. The list of chosen developed, Asian and developing countries[10] are presented in Appendix I, Table A.1. The choice of the countries for the respective sub-groups is based upon the availability of data for the respective variables. As the literature on global value chains (GVC) largely found that the share of Asian countries in global value chains (GVC) is increasing over the years (Mehta, 2018), the classification of countries into three sub-groups including developed, Asian and developing countries are done to examine the relationship between global value chains participation index (GVCPI) and innovation systems index (INNI) for the manuafacturing sector of respective countries groups. The analysis is done for 12 years from 2005 to 2016. However, for the analysis concerning the comparison of South Korean and Indian manufacturing industries, data is from 2000 to 2016.

C. Results of Regression Model and Discussion

Table 1 shows the results of the regression analysis that examine the relationship between global value chains participation index (GVCPI) and innovation systems index (INNI) for three sub-groups of countries, developed, Asian and developing countries. It needs to be highlighted that to have a comprehensive picture of pattern of interaction between global value chain (GVC) participation and innovation systems (IS) of developed and developing countries, the chosen Asian countries were excluded from the aforesaid sub-groups (Appendix I, Table A.1.) for the analysis presented in Table 1. The descriptive analysis of the variables are presented in Appendix I Table A.3. The mean value of global value chain participation index (GVCPI) is high for Asian countries which is also evidenced in the literature (Mehta, 2018). Further, the mean value of innovation systems index (INNI) is high for developed countries that largely is the reflection of the high research and development (R&D) with mean value of 1.80 with standard deviation of 0.96 as compared to

[10] The classification is done according to OECD-TiVA database. OECD-TiVA classifies the countries broadly into two groups- OECD and Non-OECD. In the present analysis, we have considered OECD countries as the group of 'developed countries' and Non-OECD countries as the group of 'developing countries' while creating another group for 'Asian economies'.

Asian economies and developing countries with the respective mean of 1.14 and 0.61 with standard deviation of 1.15 and 0.29, respectively.

It was found that for developed countries, backward linkages (FVASH) have positive impact on innovation systems index (INNI) (Table 1, Model 1) indicating that technological capabilites can also be accumulated in advanced stages with participation in global value chains by backward linkages. These results also augment the "in-out-in again" hypothesis of Lee *et al.* (2018) wherein the economies re-enter global value chains in the later stage through backward linkages after establishing local value chains. Further, it was found that organisational innovation (ORGI) have a positive and significant impact in determining the participation in global value chains (GVCPI) by developed countries. But the results for product innovation (PRODI) is negative for developed countries, which was not expected. Futher the SURE model shows that price level (PL) have a significant and positive impact in determining innovation systems index (INNI) in developed countries, probably reflective of technologically intensitve products. On the other hand, the negative coefficient of price level (PL) determines the participation of developed countries in global value chains (GVCPI) is as expected.

Result of regression analysis for the manufacturing industries from Asian countries is also presented in Table 1. The results of SURE (Table 1, model 3) and ordinary least square (Table 1, model 4) show that for Asian manufacturing industries, the impact of backward linkage (FVASH) on innovation systems index (INNI) is negative and significant, that indicates the apparent middle stage of "in-out-in again" hypothesis of Lee *et al.* (2018) wherein countries are building local value-chains. Further, the results show that the impact of high skilled labour (LABHS) and low-skilled labour (LABLS) has a positive and significant impact on both innovation systems index (INNI) and participation in global value chains index (GVCPI) of these countries. Interestingly, the results of the Breusch-Pagan test of independence is rejected at 1 percent level of significance indicating the positive correlation of 0.47 percent amongst the residuals of the two equations with global value chains participation index (GVCPI) and innovation systems index (INNI) as dependent variables in the model.

For developing countries, it was found (Table 1, Model 5) that organisational innovation (ORGI) have a positive and significant impact on determining the participation in global value chains (GVCPI). However, the model also shows that the impact of both backward

linkages (FVASH) and forward linkage (DVAFXSH) has negative and significant impact on the innovation systems index (INNI) that could be caused with the asymmetric governace relationship within GVC (Gereffi *et al.* 2005) with multinational corporations managing the production chains for cost considerations. But, it was found that high skilled labour (LABHS) and price level (PL) have a positive and sigificant impact in building the innovation systems (INNI) in developing countries implying that in the initial stage, the indigenous human capital is important for building innovation system and hence, these countries should invest in building a strong high-skilled labour force. On the other hand, it was found that medium skilled labour (LABMS) and low skilled (LABLS) labour have a positive and significant impact in determining the participation in global value chains (GVCPI) from developing countries, whereas the impact of these medium skilled labour (LABMS) and low-skilled labour (LABLS) is negative and significant on innovation sytems index (INNI). In the nutshell, for developing countries, it can be infered from the results of the analysis that the investment in human capital with different skill-intensities would help in building a relatively stronger innovation systems (high-skilled labour) and also would help in participation in global value chains (medium-skilled labour and low-skilled labour). Importantly, organisational innovation (ORGI) is found to be important factor for participation in global value chains from developing economies as is the case for developed economies. But the results of the Breusch-Pagan hypothesis of "no correlations of disturbances" was not rejected for developing countries.

The regression results also show that the impact of research and development (R&D) is positive and significant for building innovation systems (INNI) in developed and Asian countries signifying the importance of investment in research and development (R&D) for building innovation systems as has been argued extensively in the literature (Cohen and Levinthal, 1989).

Thus, the overall results of the countries-level analysis show that different factors influences the innovation systems (INNI) and participation in global value chains (GVCPI) from different countries. Specifically, it was found that (i) for developing countries, organizational innovation, medium-skilled labour and low-skilled labour plays an important role for their participation in GVC whereas high-skilled labour plays an important role in building innovation systems; (ii) for Asian economies, high-skilled labour and low-skilled labour has

a positive impact on both participation in GVC[11] and on innovation systems. (iii) For developed countries, the impact of organizational innovation and medium skilled labour plays dominant role in their participation in GVC. Interestingly, backward linkages play a dominant role in building innovation systems of developed countries.

Therefore, the results can be systematized for pattern of participation in GVC and building Innovation systems (IS) in three stages. In the initial stage, the indigenous efforts with high-skilled labour helps in building innovation systems (IS) as low-skilled labour, medium skilled labour and organizational innovation lead to participation in GVC with asymmetric governance structure. In the second stage, indigenous innovation capabilities and participation in GVC depends upon the efforts and capabilities of indigenous human capital. In the later stage, participation in GVC through backward linkages also helps in building innovation systems, whereas organizational innovation and medium skilled labour helps in participation in GVC. Thus it is inferred that the importance of human capital with different skill intensities are important at each stage of economic development for both participation in global value chains (GVC) and building innovation systems (IS).

IV. Sectoral Level Analysis: Comparison of South Korean and Indian manufacturing Industries

After analyzing the relationship between global value chains participation index (GVCPI) and the innovation systems index (INNI) for the manufacturing sector of different developed, Asian and developing economies, the need is to examine such relationship at the sectoral level. For the purpose, the manufacturing industries of South Korea and India are chosen for the analysis. The idea is to draw implications from the case of successful Korean manufacturing industry that helped Korean economy to skip the Middle Income Trap (Lee, 2013) with the entry in to the group of OECD countries in early 1990s. South Korean success in manufacturing of electronics, automobiles, shipbuilding *etc.* in a period of about two decades is well astonishing that has been examined widely (ibid). India has also transformed its economy

[11] The pattern of global production systems shows that there are evidences of tilting of global production process towards Asian economies (Mehta 2018).

TABLE 1

GLOBAL VALUE CHAINS AND INNOVATION SYSTEMS: REGRESSION RESULTS

	SURE (1)		OLS (2)		SURE (3)		OLS (4)		SURE (5)		OLS (6)	
	Developed Countries				Asian Countries				Developing Countries			
	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI
FVASH		0.23*** (0.07)		0.11 (0.07)		-1.01*** (0.11)		-0.62*** (0.14)		-0.17* (0.10)		-0.20* (0.11)
DVAFXSH		0.01 (0.06)		-0.06 (0.07)		-0.08 (0.16)		0.17 (0.19)		-1.1*** (0.07)		-1.18*** (0.08)
PRODI	-0.09* (0.05)		-0.10** (0.05)		-0.03 (0.03)		-0.002 (0.04)		0.02 (0.04)		-0.001 (0.04)	
PROCI	-0.01 (0.04)		-0.02 (0.04)		-0.05 (0.05)		-0.03 (0.06)		-0.2** (0.09)		-0.2** (0.10)	
ORGI	0.18*** (0.03)		0.18*** (0.03)		-0.17*** (0.04)		-0.14** (0.05)		0.3*** (0.10)		0.29** (0.11)	
MARKI	-0.10** (0.03)		-0.11*** (0.03)		-0.07 (0.05)		-0.01 (0.07)		-0.17*** (0.06)		-0.16** (0.06)	
LABHS	-0.12*** (0.01)	-0.06 (0.04)	-0.12*** (0.01)	-0.09** (0.43)	0.20*** (0.02)	0.42*** (0.05)	0.17*** (0.02)	0.34*** (0.05)	-0.6*** (0.09)	1.10*** (0.20)	-0.6*** (0.09)	1.06*** (0.21)
LABMS	0.09*** (0.02)	-0.03 (0.05)	0.09*** (0.02)	-0.01 (0.05)	0.09 (0.08)	-0.29** (0.13)	-0.04 (0.09)	-0.34** (0.14)	0.4*** (0.11)	-1.21*** (0.21)	0.45*** (0.12)	-1.17*** (0.22)
LABLS	-0.01 (0.01)	0.13*** (0.02)	0.01 (0.01)	0.13*** (0.02)	0.16*** (0.03)	0.50*** (0.05)	0.09** (0.04)	0.51*** (0.06)	0.5*** (0.05)	-0.7*** (0.15)	0.50*** (0.06)	-0.67*** (0.16)
PL	-0.17*** (0.05)	0.41*** (0.11)	-0.16*** (0.05)	0.4*** (0.11)	-0.09 (0.05)	-0.31*** (0.11)	-0.06 (0.06)	-0.33** (0.13)	0.7 (0.07)	0.79*** (0.11)	0.08 (0.08)	0.79*** (0.12)
Controls:												
Internet	0.05 (0.03)	0.08 (0.08)	0.06 (0.03)	0.11 (0.08)	-0.001 (0.02)	0.08*** (0.03)	-0.02 (0.02)	0.12*** (0.03)	0.01 (0.02)	-0.18*** (0.04)	0.01 (0.02)	-0.18*** (0.04)
Logistics	-0.7*** (0.12)	-0.02 (0.30)	-0.78*** (0.12)	-0.11 (0.30)	-0.6*** (0.19)	-1.16*** (0.33)	-0.5** (0.21)	-0.99** (0.36)	-1.05*** (0.19)	1.6*** (0.30)	-1.04*** (0.20)	1.60*** (0.31)
GDPPC	0.34*** (0.04)	0.26** (0.25)	0.35*** (0.04)	0.28** (0.11)	0.09** (0.03)	-0.08 (0.06)	0.2*** (0.06)	-0.18 (0.07)	-0.1 (0.06)	-0.7*** (0.11)	-0.10 (0.06)	-0.79*** (0.11)
Manf	0.11*** (0.03)	0.23*** (0.07)	0.12*** (0.03)	0.25*** (0.07)	0.31*** (0.07)	0.72*** (0.04)	0.20** (0.08)	0.67*** (0.05)	-0.3*** (0.05)	-0.18 (0.11)	-0.3** (0.05)	-0.19* (0.11)
R&D	-0.05*** (0.02)	0.15*** (0.04)	-0.05** (0.02)	0.14*** (0.04)	0.05*** (0.01)	0.21*** (0.04)	0.05* (0.02)	0.19*** (0.05)	0.15*** (0.04)	0.11 (0.08)	0.15*** (0.04)	0.13 (0.08)
const	0.67 (0.42)	-1.16 (1.07)	0.61 (0.43)	-0.91 (1.09)	4.07*** (0.33)	7.05*** (0.60)	3.6*** (0.39)	5.66*** (0.68)	6.8*** (0.79)	14.0*** (1.61)	6.92*** (0.84)	14.3*** (1.68)
Country & Time dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
B-P Test (Chi2)	-0.0874*				0.4665***				-0.0294			
R-Sq	0.41	0.40	0.40	0.41	0.88	0.97	0.89	0.97	0.70	0.89	0.70	0.89
Obs	420	420	420	420	84	84	84	84	144	144	144	144
F-Stat			(+)***	(+)***			(+)***	(+)***			(+)***	(+)***
Chi2	(+)***	(+)***			(+)***	(+)***			(+)***	(+)***		

Note: *1. ***,**,* means the coefficients are significant at 1 percent, 5 percent and 10 percent, respectively.*

2. Standard error is shown in brackets. 3. See Appendix I, Table A.1. for the classification of the countries in three subgroups.

from primarily agrarian towards manufacturing and relatively large service sector. The manufacturing sector of South Korea and India was classified according to technology-based industrial classification provided by OECD (2011)[12]. Thus, the two sub-groups high-technology intensive industries and low technology intensive industries for both South Korea and India are examined and the results of the regression models are presented in Table 2[13]. The data is from 2000 to 2016.

Considering South Korean manufacturing industries, it was found that for its high-technology intensive industries (Table 2, Model 1), backward linkage (FVASH) and high skilled labour (LABHS) has positive impact on innovation systems index (INNI), whereas both product innovation (PRODI) and process innovation (PROCI) along with high-skilled labour (LABHS) have positive and significant impact on global value chain participation index (GVCPI). The results were also estimated using the ordinary least square method (Table 2, model 2) that shows the results are robust. Specifically, electronics industry of South Korea is one of the successful high-technology industry of the country that began as an assembler of imported components and parts during early 1960s (Hobday 1995, 1998; Lee and Lim 2001, Lee and Mathew 2012) and emerged as Original Design Manufacturers (ODM)/ Original Brand Manufacturers (OBM) (ibid) within two decades that signifies the importance of product and process innovation in the later stages with simultaneous development of its innovation system (Lee and Mathew 2012).

The results for low-tech manufacturing industries from South Korea

[12] Low tech industries included in the analysis are Food products, beverages and tobacco; Textiles, wearing apparel, leather and related products; Wood and paper products, printing; and Basic metals and fabricated metal products while High tech industries included in the analysis are Chemicals and non-metallic mineral products; Computers, Electronic and electrical equipment; Machinery and equipment; and Transport equipment.

[13] However, for the model that compared the high and low technology industries for South Korea and India, the following three control variables were included instead. Initial Value added of respective manufacturing (Ivapca); share of value added of the respective manufacturing industry in the total value-added of the manufacturing industries of the respective countries (Indva); and share of capital to total value added of the respective manufacturing industry (capva). These three variables were constructed from the WIOD database. (Appendix 1, Table A.2.)

are very different as compared to its high-technology intensive sub-group. It needs to be highlighted that South Korea has a relatively more cases of successful firms/ industries in high-technology intensive industrial sub-section as compared to low-technology intensive sub-group. The results show that for South Korean low-technology intensive industries, both backward linkages (FVASH) and forward linkage (DVAFXSH) does not have positive impact on innovation systems (INNI) of these industries (Table 2, Model 3,4). On the other hand, process innovation (PROCI) has positive and significant impact on South Korean low technology intensive industries global value chain participation index (GVCPI). However, the price level (PL) also has positive impact on both the global value chain participation index (GVCPI) and innovation systems index (INNI) of the Korean low-technology intensive manufacturing sector. Further, Breusch-Pagan test of independence of correlation between the residuals of the two equations of the model for the Korean low-technology intensive industries was rejected at 1 percent, indicating the positive correlation of residuals.

Further, Table 2 also shows the regression results for Indian high-technology intensive and low-technology intensive manufacturing industries using SURE and OLS regression analysis. Overall the results are robust. For the Indian high-technology intensive industries, it was found (Table 2, Model 5) that both backward linkages (FVASH) and forward linkages (DVAFXSH) have positive and significant impact in determining innovation systems index (INNI) while none of the innovation related variable has a significant impact on global value chain participation index (GVCPI).

For Indian low-technology intensive sub-group, the regression results (Table 2, Model 7) show that backward linkage (FVASH) has negative while forward linkage (DVAGXSH) has positive on innovation systems index (INNI). Importantly, it was found that human capital possessing different skill intensities like high-skilled labour (LABHS), medium – skilled labour (LABMS) and low-skilled labour (LABLS) has positive impact on innovation systems index (INNI) of low-technology intensive industries. It was also found that for Indian low-technology intensive industries, the coefficient of price level (PL) is negative and significant in determining global value chain participation index (GVCPI) implying the cost-competitive advantage of these industries. These results can be examined akin with the textiles and garment manufacturers from Vietnam and Bangladesh, that also participate in global value chains

TABLE 2

SOUTH KOREAN AND INDIAN MANUFACTURING INDUSTRIES: A COMPARISON

	South Korea Manufacturing Industries								India Manufacturing Industries							
	HIGH TECHNOLOGY INDUSTRIES				LOW TECHNOLOGY INDUSTRIES				HIGH TECHNOLOGY INDUSTRIES				LOW TECHNOLOGY INDUSTRIES			
	SURE (1)		OLS (2)		SURE (3)		OLS (4)		SURE (5)		OLS (6)		SURE (7)		OLS (8)	
	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI	GVCPI	INNI
FVASX		1.4*** (0.23)		0.87** (0.27)		-1.8*** (1.97)		-1.2*** (0.23)		0.09* (0.05)		0.06 (0.06)		-0.18*** (0.01)		-0.15*** (0.01)
DVAFXSH		0.12 (0.16)		-0.02 (0.19)		-0.5*** (0.05)		-0.6*** (0.06)		0.66*** (0.03)		0.66*** (0.03)		0.04** (0.02)		0.07** (0.02)
PRODI	0.19** (0.07)		0.16* (0.09)		-0.3** (0.12)		-0.36* (0.14)		0.89 (1.93)		0.98 (2.11)		-8.6* (3.6)		-14.8*** (4.5)	
PROCI	0.2*** (0.37)		0.15*** (0.04)		0.11** (0.03)		0.07* (0.04)		0.51 (3.55)		0.68 (3.89)		-0.9 (1.25)		-2.3 (1.57)	
ORGI	0.02 (0.09)		-0.06 (0.11)		-0.15*** (0.04)		-0.17*** (0.05)		-1.65 (6.52)		-1.97 (7.15)		-0.54 (0.71)		1.37 (0.90)	
MARKI	-0.08 (0.09)		-0.11 (0.12)		0.13 (0.11)		0.23* (0.13)		-		-		-			
LABHS	0.75* (0.42)	1.16 (1.03)	1.25** (0.47)	2.35* (1.13)	0.08 (0.33)	1.11 (0.73)	-0.03 (0.37)	1.11 (0.79)	-0.51 (0.31)	-0.19 (0.16)	-0.49 (0.34)	-0.20 (0.18)	0.64 (0.49)	0.74*** (0.04)	-0.46 (0.58)	0.74*** (0.05)
LABMS	0.32 (0.42)	0.36 (1.05)	0.51 (0.47)	0.75 (1.14)	-1.3 (0.82)	-0.83 (1.85)	-0.90 (0.91)	0.26 (2.02)	-0.71 (0.30)	0.04 (0.12)	-0.73 (0.33)	0.02 (1.13)	-0.38 (1.62)	1.40*** (0.12)	-2.7 (1.96)	1.32*** (0.14)
LABLS	0.26* (0.13)	0.24 (0.32)	0.41* (0.15)	0.62 (0.35)	0.005 (0.20)	0.40 (0.45)	-0.12 (0.23)	0.51 (0.49)	-0.41 (0.21)	-0.3*** (0.07)	-0.38 (0.23)	-0.30*** (0.08)	8.01* (4.63)	2.63*** (0.13)	10.5* (5.71)	2.74*** (0.14)
PL	0.17* (0.09)	-0.4* (0.15)	0.13 (0.10)	-0.41* (0.17)	0.24*** (0.06)	0.6*** (0.11)	0.16* (0.07)	0.6*** (0.12)	0.45 (0.41)	-0.53*** (0.18)	0.40 (0.44)	-0.48** (0.19)	-0.65*** (0.20)	-0.2*** (0.04)	-0.55** (0.23)	-0.2*** (0.04)
Controls																
Ivapca	0.21** (0.07)	-0.15 (0.13)	0.25** (0.08)	0.01 (0.14)	0.2*** (0.05)	0.003 (0.08)	0.2** (0.06)	-0.07 (0.09)	0.19 (0.11)	0.25*** (0.05)	0.20 (0.12)	0.25*** (0.05)	0.29*** (0.08)	0.07*** (0.02)	0.28*** (0.09)	0.09*** (0.02)
Indva	-0.08 (0.14)	0.80* (0.38)	0.04 (0.15)	0.85* (0.42)	0.05 (0.06)	0.69*** (0.08)	0.04 (0.07)	0.6*** (0.09)	-0.03 (0.24)	-0.003 (-0.05)	-0.04 (0.26)	-0.01 (0.07)	0.31*** (0.08)	0.11*** (0.02)	0.13 (0.09)	0.10*** (0.02)
Capva	-0.02 (0.09)	-0.53* (0.22)	-0.13 (0.11)	-0.79*** (0.25)	0.3*** (0.07)	0.88*** (0.18)	0.4*** (0.08)	0.6*** (0.20)	-0.04 (0.20)	0.17* (0.07)	-0.02 (0.22)	0.16* (0.08)	0.31* (0.12)	0.06* (0.03)	0.30** (0.13)	0.09** (0.03)
Const	0.47 (1.03)	5.2* (2.69)	1.77 (1.16)	8.47*** (2.99)	-3.1** (1.20)	1.02 (2.67)	-2.9** (1.33)	2.8 (2.9)	0.16 (9.06)	1.22* (0.71)	0.72 (9.93)	1.23 (0.77)	41.8* (18.0)	8.67*** (17.5)	56.4* (22.3)	8.51*** (0.53)
Industry /time d	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
B-P Test (Chi2)	-0.3945**				0.4388***				-0.00867				0.5087***			
R-Sq	0.87	0.84	0.88	0.85	0.89	0.87	0.89	0.88	0.83	0.95	0.83	0.95	0.95	0.99	0.95	0.99
Obs	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
F-Stat			(+)***	(+)***			(+)***	(+)***			(+)***	(+)***				
Chi2	(+)***	(+)***			(+)***	(+)***			(+)***	(+)***			(+)***	(+)***	(+)***	(+)***

Note: *1. ***,** means the coefficients are significant at 1 percent, 5 percent, respectively.*
2. values in brackets are standard error.

due to availability of cost effective low-and medium skilled labour (Lall 2001). Furthermore, growth of Maquiladoras in Mexico by United State's transnational companies (Castillo and Szirmai 2016) were also due to the availability of cheap labour that largely engage in assembly processes for the multinational companies, especially from the United States.

Hence, South Korea with proximity in high-technology intensive industries, the impact of human capital (LABHS and LABLS) and innovation (PRODI and PROCI) are significant in determining global value chain participation index (GVCPI) while the high-skilled labour (LABHS) is important for innovation systems index (INNI) of the sub-sector.

For Indian low-technology intensive industries, low skilled labour (LABLS) and price level (PL) are the factors that determines global value chain participation index (GVCPI) and human capital (LABHS, LABMS and LABLS) have positive impact on its innovation systems index (INNI). Therefore, it is evident that human capital acts an important factor for both global value chain participation (GVCPI) and innovation systems index (INNI).

V. Conclusion

The paper aims to examine the relationship between indicators of global value chain participation index (GVCPI) and innovation systems index (INNI) for the manufacturing industry at two level of aggregation. The chosen countries were classified into developed, Asian and developing economies, with a focus on two Asian countries, namely South Korea and India. Increasing participation of Asian economies in the global value chains in recent years also raises concerns of deciphering the factors causing the change that are largely assumed to be related to indigenous innovation systems. Existent literature (Pietrobelli and Rabellotti 2009) found the relationship between global value chains (GVC) and innovation systems (IS) as non-linear wherein the participating in global value chains (GVC) contributes to *learning* and improving local innovation systems (IS) that also lead to increasing participation in global value chains (Lee *et al.* 2018).

The country level analysis indicates the impact of varied factors leading to participation in GVC and IS for different country's groups. It can be inferred from the analysis that for developing countries, low-

skilled labour and organizational innovation lead to participation in GVC that is followed with a stage in which both low-skilled labour and high-skilled labour becomes important, as has been in case of aggregate Asian economies. However developed economies, that largely govern the global value chains participation in GVC depends upon the factors like organizational innovation and medium skilled labour. Furthermore, for building innovation systems, it was found that in the initial stages as can be inferred from the case of developing countries, high-skilled labour plays a dominant role followed with a second stage wherein both high-skilled labour and low-skilled labour contribute in building innovation systems. But in the advanced stages, even participation in GVC with backward linkages also contributes in building innovation systems.

For sector level analysis, an attempt was made to examine the high-technology intensive and low-technology intensive sub-sectors of the manufacturing industries from South Korea and India that largely substantiate the result of country-level analysis. Results of high-technology intensive sub-group of South Korean manufacturing sector show that product and process innovation also lead this sub-sector to participate in GVC, while high skilled labour is also an important factor that helps in building the innovation systems of advanced industrial sub-group. For the South Korean low-technology intensive subgroup, again the cost effectiveness in the form of process innovation led to participation in GVC. Similar is the results for the Indian low technology industrial subgroup wherein the price competitiveness is a dominant factor of their participation in GVC and high-skilled labour along with medium and low skilled labour helps in building innovation systems.

Hence, from the analysis a systematize pattern of contribution of varied factors for participation in GVC and building innovation system (IS) is highlighted, reflecting different stages of development. In the initial stage, it is the low skilled labour, medium skilled labour, process innovation and price level that plays an important part for participation in GVCs. In the middle stage, the role of high-skilled labour increases for participation in GVCs. At the advanced stage, the participation in GVC, is largely found to be determined due to innovation (product, process and organizational innovation) and labour (high-skilled and medium skilled). These results signify to varied policy implications according to the stage of development of entities to participate in global value chains (GVC) that also contributes simultaneously for building

domestic innovation systems (IS). The results also infer that for building innovation system, initially the role of high-skilled labour predominates, followed with the participation in GVC, mainly through backward linkages in advanced stages.

These results, thus depicts the pattern of factors determining GVC participation and building innovation systems at different stages of development. However, more empirical evidences for different industries belonging to different countries would further help in substantiating these results even more profoundly, that would be the task for future research.

Thus to conclude, the emphasis of the policy makers of different countries should be varied although specific depending upon the stage of participation of entities in GVC and the accumulated innovation capabilities.

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Appendix 1

Table A.1
List of countries in Regression Analysis

Developed	Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxemburg, Mexico, Netherland, New Zealand, Norway, Poland, Portugal, Slovak, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
Developing	Argentina, Brazil, Brunei, Bulgaria, Cambodia, Colombia, Costa Rica, Croatia, Cyprus, Kazakhstan, Malta, Morocco, Peru, Romania, Russia, Saudi Arabia, South Africa, Tunisia
Asian	China, India, Hong Kong, South Korea, Indonesia, Malaysia, Philippines

Note: OECD and Non-OECD countries (OECD-TiVA) are taken as Developed and Developing countries, respectively with excluding the once taken in the separate group of Asian countries.

TABLE A. 2

GLOBAL VALUE CHAINS AND INNOVATION SYSTEMS: VARIABLE USED IN THE ANALYSIS

		Definition and construction of variable	Source
GVC Participation Index			
Backward Linkage	FVASH	It is defined as the foreign value added embodied in gross exports as a percentage of total gross exports	TiVA
Forward Linkage	DVAFXSH	It is defined as the domestic value added embodied in the exports of third country as a percentage of the gross exports of the source country.	TiVA
Innovation System Index			
Product Innovation	PRODI	It captures the percentage of product innovators in manufacturing.	UNESCO-UIS statistics
Process Innovation	PROCI	It captures the percentage of process innovators in manufacturing.	UNESCO-UIS statistics
Organizational Innovation	ORGI	It captures the percentage of firms that implemented organizational innovation.	UNESCO-UIS statistics
Marketing Innovation	MARKI	It captures the percentage of firms that implement marketing innovation.	UNESCO-UIS statistics
High-skilled labour	LABHS	High-skilled labour compensation as a share of total labour compensation	WIOD' 2014
Medium-skilled labour	LABMS	Medium-skilled labour compensation as a share of total labour compensation	WIOD' 2014
Low-skilled labour	LABLS	Low-skilled labour compensation as the share of total labour compensation	WIOD' 2014
Price level	PL	'Price level ratio of PPP conversion factor (GDP) to market exchange rate'	World Development Indicators
Control variables (For manufacturing for three sub-groups of countries (Analysis in Section 3))			
Internet	Internet	Individuals using the internet as a percentage of population	World Development Indicators
Logistics	Logistics	Logistics Performance Index	World Development Indicators
Initial GDPPC	GDPPC	GDP per capita, PPP (constant 2011 $)	World Development Indicators
Manufacturing Share	Manf	Manufacturing value added as percentage of GDP	World Development Indicators
R&D intensity	R&D	Research and Development expenditure as a percentage of GDP	World Development Indicators
Control variables (For manufacturing of South Korea and India (Analysis in Section 4))			
Initial size of manufacturing	Ivapca	Value added of respective manufacturing sector (at constant prices)	WIOD' 2016
Share of Manufacturing	Indva	Share of value-added of the respective manufacturing industry in the total value-added of the sector for the respective country.	WIOD' 2016
Capital share	Capva	Share of capital to total value added of the respective manufacturing industry	WIOD' 2016

TABLE A.3

DESCRIPTIVE ANALYSIS FOR CHOSEN DEVELOPED, DEVELOPING AND ASIAN ECONOMIES

Variables	Developed		Developing		Asia	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
FVASH (%)	33.72	10.38	27.39	14.35	33.90	10.70
DVAFXSH (%)	13.94	4.85	14.38	7.20	15.07	4.11
PRODI (%)	28.14	9.89	20.63	17.08	21.36	12.66
PROCI (%)	27.58	9.73	24.33	16.13	20.93	15.07
ORGI (%)	27.16	12.00	24.20	17.64	31.43	15.92
MARKI (%)	25.53	11.98	20.33	14.38	32.23	17.84
LABHS (share)	0.21	0.14	0.07	0.09	0.13	0.15
LABMS (share)	0.44	0.24	0.18	0.24	0.23	0.20
LABLS (share)	0.17	0.16	0.23	0.30	0.20	0.23
PL (Ratio)	0.97	0.27	0.59	0.15	0.47	0.18
Internet (%)	70.90	17.68	44.56	18.70	42.83	29.27
Logistics (Score)	3.58	0.38	2.88	0.31	3.23	0.53
GDPPC (US$)	36402.13	14624.1	18774.04	6774.42	17950.86	15002.59
Manf (%)	14.23	4.55	13.08	3.76	20.77	9.06
R&D (%)	1.80	0.96	0.61	0.29	1.14	1.15
GVCPI (%)	47.66	9.01	41.78	10.95	48.98	9.30
INNI (%)	27.10	9.84	22.37	14.05	26.49	14.17

TABLE A.4

DESCRIPTIVE ANALYSIS FOR MANUFACTURING INDUSTRIES OF SOUTH KOREA AND INDIA

Variables	South Korea				India			
	High Tech		Low Tech		High Tech		Low Tech	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
FVASH(%)	38.47	8.38	30.34	7.73	30.71	8.34	17.86	9.97
DVAFXSH (%)	3.30	2.94	0.71	0.55	1.81	0.70	0.94	0.59
PRODI (%)	37.70	18.25	22.73	10.31	29.35	10.77	29.02	5.91
PROCI (%)	18.93	9.89	10.53	7.70	28.77	9.01	21.42	7.43
ORGI (%)	33.57	12.26	18.10	13.77	74.45	17.47	66.72	29.67
MARKI (%)	19.01	12.83	18.59	15.07	70.15	17.64	58.02	33.63
LABHS (share)	0.43	0.06	0.37	0.61	0.52	0.09	0.13	0.08
LABMS (share)	0.49	0.03	0.49	0.02	0.34	0.09	0.38	0.06
LABLS (share)	0.07	0.03	0.13	0.04	0.12	0.34	0.48	0.13
PL (Ratio)	99.25	18.62	91.52	22.07	94.73	13.67	91.11	19.88
Ivapca (US$)	9252662	4675132	9654903	1.03e+07	34836.7	16630.14	12101.2	12776.3
Indva (share)	8.39	1.97	4.90	2.99	6.43	2.53	9.67	4.42
Capva (share)	251.98	98.65	287.77	67.81	425.96	58.62	414.02	148.77
GVCPI (%)	41.77	8.61	31.05	7.91	32.53	8.52	18.80	10.71
INNI (%)	27.30	11.89	17.49	10.43	50.68	12.67	43.8	17.29